CHAPTER 11

Stock Products

Options on common stocks have been traded in the United States since the 1790s. Originally, trading took place in the over-the-counter market. Put/call dealers would advertise their prices in the financial press, and interested buyers would call a dealer. These contracts were not standardized with respect to exercise prices or expiration dates. Without standardization, option positions were often difficult to unwind prior to expiration. An investor wanting to reverse his option position was forced to negotiate with the dealer with whom the original trade was made.

On April 26, 1973, the Chicago Board Options Exchange (CBOE) became the world's first organized secondary market for stock options. The beginnings were modest. The "exchange" was in a small smokers' lounge off the main floor of the Chicago Board of Trade. The only options traded were calls,[1] and calls were available only on 16 New York Stock Exchange (NYSE) stocks. The market was an immediate success. By 1975, the American Stock Exchange (AMEX) and the Philadelphia Stock Exchange (PHLX) began listing stock options, followed shortly thereafter by the Pacific Coast Exchange (PCE) and the NYSE. Today, calls and puts trade in the United States on over 2,200 hundred different stocks and on five exchanges. Worldwide, stock options trade on over 50 exchanges in 38 different countries. Futures contracts on individual stocks also trade on a handful of exchanges worldwide, but their popularity pales by comparison. Due to a regulatory dispute, stock futures did not begin trading in the United States until November 2002.[2]

This chapter has three sections. In the first section, the trading activity of the major stock derivatives markets worldwide is presented. U.S. stock option mar-

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[1] The decision by the CBT to apply to the SEC for the trading of calls rather than calls and puts was a political one. At the time, short selling of stocks was regarded with suspicion. Rather than jeopardize its chances of having *any* stock option trading approved, the CBT's application was confined to options whose value increased as the stock price goes up.

[2] Until late 2000, trading in single stock futures was prohibited in the United States by virtue of the Johnson-Shad Accord (1984). In December 2000, Congress passed the Commodity Futures Modernization Act that, among other things, repealed the ban on single-stock futures, clearing the path for trading in the U.S. stock futures began trading in the OneChicago and NQLX markets on November 8, 2002.

kets are discussed in detail. Stock option contract specifications are also provided. In the second section, valuation principles based on the materials of Chapters 3 through 7 are summarized. For derivatives on common stocks, the discrete flow valuation framework is most appropriate. In the United States, cash dividend payments are made quarterly. The third section contains a discussion of stock option trading and risk management strategies. Dividend spread strategies, stock price collars, and variable prepaid forward contracts are considered. Also considered are strategies involving corporations buying and selling exchange-traded and OTC options on their own shares. The chapter concludes with a brief summary.

MARKETS

Derivative contracts on individual common stocks trade both on exchanges and in the OTC market. Of the two contract markets, the stock option market is by far the most active in the United States. For the calendar year 2003, stock options accounted for 99.7% of all single stock futures and option trading.[3]

Stock futures trade on two exchanges in the United States—the OneChicago Exchange (ONE) and NQLX.[4] Both exchanges are fully electronic. OneChicago is a joint venture of the Chicago Board Options Exchange, the Chicago Mercantile Exchange, and the Chicago Board of Trade. During 2003, it had trading volume surpassing 1.6 million contracts. The NQLX is a wholly-owned company of Euronext.liffe, which, in turn, is a wholly-owned subsidiary of Euronext NV. Its trading volume during 2003 was approximately 60% of that of OneChicago.

Stock options trade on five exchanges in the United States—the Chicago Board Options Exchange (CBOE), the American Stock Exchange (AMEX), the Pacific Exchange (PCE), the Philadelphia Exchange (PHLX), and the International Securities Exchange (ISE).[5] The ISE is fully electronic. Figure 11.1 provides a breakdown of contract volume by exchange for the year 2003. The ISE had the greatest trading volume with 30% of all U.S. stock option trading volume. The CBOE was next with 26%. The AMEX had 21%, the PHLX 13%, and the PCX 10%.

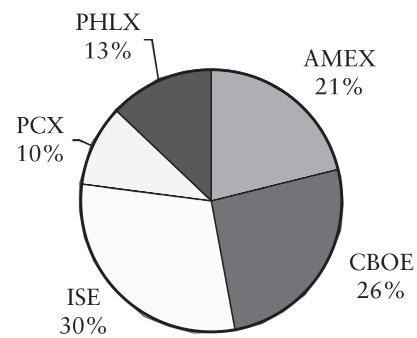
As of December 2003, 2,227 stocks had options listed on exchanges in the United States. The decision about whether to list options on a particular stock rests only with the exchange. The firm/stock must satisfy certain listing criteria. The CBOE, for example, requires that the firm has:

[3] Historical statistics for single stock futures and options trading in the United States are available on the website of the Options Clearing Corporation (www.optionsclearing.com).

[4] U.S. stock futures and stock option trades clear through the Option Clearing Corporation or OCC. Founded in 1973, the OCC is the largest clearing organization in the world for single stock options and futures and was the first clearing house to receive an AAA credit rating from Standard & Poor's Corporation. Operating under the jurisdiction of the Securities and Exchange Commission and the Commodity Futures Trading Commission, OCC is jointly owned by the American Stock Exchange, Chicago Board Options Exchange, International Securities Exchange, Pacific Exchange and Philadelphia Stock Exchange.

[5] The New York Stock Exchange (NYSE) made markets in stock options until April 1997 when it sold its market to the CBOE and reduced the number of U.S. markets from five to four. With the ISE launching trading of stock options on May 26, 2000, the number of exchanges returned to five.

FIGURE 11.1 Share of total U.S. stock option trading volume accounted for by each option exchange during the calendar year 2003.



Source: www.optionsclearing.com.

1. A minimum of seven million shares outstanding not including those held by insiders.
2. A minimum of 2,000 shareholders.

In addition, it requires that stock be:

3. Traded at least 2,400,000 shares in the last 12 months.
4. Closed at a market price of at least \$7.50 per share for the majority of the business days during the last three months.[6]

To identify new stock options, the CBOE monitors the trading activity of all stocks satisfying the listing criteria. Among the factors considered in gauging the market's potential interest are the stock's trading volume and return volatility.[7] The higher the trading volume and the greater the volatility, the greater the potential interest. Once the CBOE decides list options on a particular stock, it registers with the SEC. Trading begins a few days later. As a matter of courtesy, the CBOE sends a letter informing the firm of its decision.

Stock Futures

Stock futures trade in a number of countries worldwide, with the U.S. markets being the most active. Table 11.1 provides the specifications of the single-stock futures contracts traded on the OneChicago Exchange. Each futures is written on 100 shares of stock, with prices quoted in pennies per share. They trade from 8:15AM to 3PM CST. Futures contracts on a particular stock are on the quarterly expiration cycles Mar/Jun/Sep/Dec. At any time the next two quarterly

[6] Chicago Board Options Exchange *Constitution and Rules* (May 2002), Paragraph 2113.
[7] Mayhew and Mihov (2004) provide empirical support for the proposition that volume and volatility in the underlying stock market are important in a stock option exchange's listing decision.

expirations as well as the next two monthly serial expirations are listed. The contracts expire on the third Friday on the contract month. Physical delivery of the underlying shares takes places three business days after contract expiration.

TABLE 11.1 Selected terms of single stock futures contract traded on OneChicago Exchange.

Contract size	100 shares of underlying stock
Minimum price fluctuation (tick size)	$0.01 × 100 shares = $1.00
Regular trading hours	9:15 AM–4:02 PM Eastern Time
Position limits	None prior to the last five trading days prior to expiration. During the last five trading days, either 13,500 net contracts or 22,500 net contracts (long or short) as per CFTC requirements.
Daily price limits	None
Reportable position limit	200 contracts
Contract months	Two quarterly expirations and two serial months trade at all times for a total of four expirations per product class. OneChicago follows the quarterly cycle of March (H), June (M), September (U), and December (Z). The serial months traded are the two nearby non-quarterly contract months.
Expiration date/last trading day	Third Friday of contract month or, if such Friday is not a business day, the immediately preceding business day.
Settlement/delivery	Physical delivery of underlying security on third business day following the last trading day.
Additional Information	
Margin requirements	Initial and maintenance margin requirement of 20% of the cash value of the contract. Certain offsets may apply.
Short sale advantages	No uptick required to initiate a short position. No stock borrowing costs or risks.
Clearing and settlement	Trades executed at OneChicago are cleared and settled by the Options Clearing Corporation (OCC) or by Chicago Mercantile Exchange Inc. (CME).
U.S. Government regulator	OneChicago is jointly regulated by the Commodity Futures Trading Commission (CFTC) and the Securities and Exchange Commission (SEC).

Stock Options

The stock options traded in the United States are also, for the most part, standardized products. Each stock option contract is written on 100 shares of stock, has its price reported in pennies per share,[8] expires on the Saturday after the third Friday of the contract month, and is American-style. For stocks with a share price in excess of $25, exercise price increments are usually in $5 increments, and, for share prices less than $25, exercise prices are in $2.50 increments. Options on a particular stock are on one of three quarterly expiration cycles (Jan/Apr/Jul/Oct, Feb/May/Aug/Nov, or Mar/Jun/Sep/Dec), and the two nearest contract months on the quarterly cycle are listed at any time. In addition, there will be options listed on the two nearby months, and, in the event that one of the two nearest months is on the quarterly cycle, the next quarterly expiration will also be traded. Dell's options, for example, are on the Feb/May/Aug/Nov cycle. This means that, if we are standing at the end of December (after the December options have expired), January, February, May, and August option expirations will be traded. Under these rules, stock options are short-term, with times to expiration less than nine months. That is not to say that longer term options do not exist. In the 1980s, the CBOE, in response to investor demand, began trading "Long-term Equity Anticipation Securities," more popularly known as "Leaps." Leaps, by convention, expire in the month of January, and have times to expiration up to three years.

Stock options are normally "unprotected" from cash dividend payments on the underlying stock. Dividend payments during the option's life reduce the price of the stock and hence reduce (increase) the value of the call (put). In the event of extraordinarily large cash dividend distributions (i.e., 5% of the prevailing stock price); however, the Options Clearing Corporation (OCC) "protects" the value of option contracts by adjusting the exercise prices of outstanding option series downward by the amount of the cash dividend payment.[9] Such an adjustment largely preserves the value of the option. Stock options are "protected" from the effects of stock splits and stock dividends. When a firm splits its shares or pays a stock dividend, the option's exercise price and open interest are adjusted accordingly. A 5-for-4 stock split (or a 25% stock dividend), for example, reduces a $50 exercise price to $40 and increases the number of options outstanding by 25%. In the event of the stock split/stock dividend produces a non-integer exercise price, the exercise price is rounded to the nearest 1/8.

The terms of stock option contracts are also adjusted in the event of a corporate restructuring or acquisition. On April 30, 2004, for example, Abbott Laboratories ("ABT") distributed the shares of Hospira, Inc. ("HSP") to ABT shareholders. The underlying deliverable security for outstanding ABT option

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[8] Under current exchange rules, the minimum tick size for options trading up to $3 is five cents and for options trading above $3 is 10 cents.

[9] On July 20, 2004, Microsoft Corporation ("MSFT") announced a special cash dividend of $3 per share. At the time, the MSFT share price closed at $28.32, so the distribution amounted to 10.6% of the prevailing share price. On November 9, 2004, Microsoft shareholders approved a $3 special cash dividend payable on December 2, 2004, to shareholders of record on November 17, 2004. Therefore, as of November 15, 2004 (i.e., the ex-dividend date of Microsoft's shares), the exercise prices of all MSFT option series were reduced by $3.

series became 100 shares of ABT and 10 shares of HSP. For mergers and acquisitions, the shares of the target firm are adjusted, with the nature of the adjustment depending on how the bidding firm pays for the shares of the target firm. If the bidding firm acquires the shares of the target using its own shares to pay for the shares of the target firm, an adjustment is made to the number of deliverable shares. On April 26, 2004, for example, AngloGold Limited acquired Ashanti Goldfields Company Limited, paying 0.29 shares of the newly formed AngloGold Ashanti Limited (AU). Hence, the deliverable security on outstanding Ashanti option series became 29 shares of AU. If the bidding firm pays cash for the target firm, the adjustment is severe in the sense that the target firm's share price becomes the cash offer price. On March 29, 2004, for example, Henkel KGaA acquired the shares of Dial Corporation (DL) for $28.75 in cash. The deliverable security on outstanding DL option series therefore became $28.75 in cash. While the outstanding option contracts expire at their normal time, in-the-money options should be exercised immediately since there is no prospect of earning more money (i.e., the security price is fixed). Out-of-the-money option prices immediately go to 0. These three adjustments are only examples of what may occur. Many restructurings and acquisitions have more complicated terms, and, consequently, the revisions to the terms of stock option contracts become more complicated. A panel from the OCC's Securities Committee[10] attempts to make each of these adjustments in an equitable fashion for all parties concerned. Details of all contract adjustments can be found on the OCC's website, www.optionsclearing.com.

Table 11.2A (11.2B) contains a summary of trading of Dell stock options (leaps) midday on Tuesday, January 2004. The row in Table 11.2A is for the January 2004 call and put with an exercise price of 5. The expiration month and the exercise price are reported in the columns headed "Calls" and "Puts." Dell has four expiration months listed—January 2004, February 2004, May 2004, and August 2004. Dell's options are on the Feb/May/Aug/Nov quarterly expiration cycle. According to the rules described earlier, this means the January, February, May, and August options should be traded. The first five characters of the term in parenthesis is the option series ticker symbol. The call's ticker symbol, for example, is "DLYAA." Note that each ticker symbol in the table is unique. This is its identifier for trading purposes. The table shows that neither the call nor the put traded on January 6, at least as of the time the prices were downloaded (i.e., their volumes of trading are 0). Both options have traded at some time in the past, however, since the call has open interest of 580 and the put has open interest of 245. The call has a bid/ask price quote of 30.00/30.10. Since the current stock price quotes are 35.05/35.06, there is no arbitrage price violation. The last trade price, 28.60, lies outside the option's prevailing bid/ask quotes. This merely indicates that the market price of the option has moved since the time of the last trade. When the last trade occurred cannot be inferred from the information in the table. All that can be inferred is that the trade did not occur on January 6, 2004.

[10] The panel consists of two representatives from the exchanges on which the affected option is traded.

TABLE 11.2A Summary of price, volume, and open interest information for Dell stock options drawn from www.cboe.com at 1:53 PM on January 6, 2004. Underlying stock has contemporaneous bid (ask) price of 35.05 (35.06).

Calls	Last Sale	Bid	Ask	Vol	Open Int
04 Jan 5.00 (DLY AA-E)	28.60	30.00	30.10	0	580
04 Jan 7.50 (DLY AU-E)	27.40	27.50	27.60	0	935
04 Jan 10.00 (DLY AB-E)	25.60	25.00	25.10	0	2,554
04 Jan 12.50 (DLY AV-E)	22.30	22.50	22.60	0	1,872
04 Jan 15.00 (DLY AC-E)	19.90	20.00	20.10	0	2,886
04 Jan 17.50 (DLY AW-E)	17.30	17.50	17.60	0	2,554
04 Jan 20.00 (DLY AD-E)	14.50	15.00	15.10	0	10,362
04 Jan 22.50 (DLQ AX-E)	11.70	12.50	12.60	0	4,120
04 Jan 25.00 (DLQ AE-E)	10.20	10.00	10.10	2	22,611
04 Jan 27.50 (DLQ AY-E)	7.70	7.50	7.60	0	32,333
04 Jan 30.00 (DLQ AF-E)	5.10	5.00	5.10	2	42,340
04 Jan 32.50 (DLQ AZ-E)	2.65	2.55	2.65	140	47,599
04 Jan 35.00 (DLQ AG-E)	0.55	0.55	0.65	1,490	126,530
04 Jan 37.50 (DLQ AT-E)	0.05	0.00	0.05	0	49,257
04 Jan 40.00 (DLQ AH-E)	0.05	0.00	0.05	0	42,460
04 Jan 42.50 (DLQ AS-E)	0.05	0.00	0.05	0	255
04 Jan 45.00 (DLQ AI-E)	0.05	0.00	0.05	0	8,573
04 Jan 50.00 (DLQ AJ-E)	0.10	0.00	0.05	0	9,076
04 Feb 20.00 (DLY BD-E)	14.90	15.00	15.20	0	1,313
04 Feb 22.50 (DLQ BX-E)	12.30	12.50	12.70	0	1,165
04 Feb 25.00 (DLQ BE-E)	8.50	10.00	10.20	0	1,954
04 Feb 27.50 (DLQ BY-E)	6.80	7.60	7.70	0	1,657
04 Feb 30.00 (DLQ BF-E)	5.40	5.20	5.30	0	2,477
04 Feb 32.50 (DLQ BZ-E)	3.20	3.00	3.10	438	15,854
04 Feb 35.00 (DLQ BG-E)	1.45	1.30	1.40	88	32,620
04 Feb 37.50 (DLQ BT-E)	0.40	0.35	0.45	3,784	23,799
04 Feb 40.00 (DLQ BH-E)	0.10	0.05	0.10	0	8,146
04 Feb 42.50 (DLQ BS-E)	0.05	0.00	0.05	0	1,285
04 Feb 45.00 (DLQ BI-E)	0.05	0.00	0.05	0	1,318
04 May 20.00 (DLY ED-E)	15.00	15.10	15.20	0	2,194
04 May 22.50 (DLQ EX-E)	12.40	12.60	12.80	0	1,066
04 May 25.00 (DLQ EE-E)	9.50	10.20	10.40	0	862
04 May 27.50 (DLQ EY-E)	7.40	7.90	8.00	0	695
04 May 30.00 (DLQ EF-E)	5.30	5.70	5.80	0	1,981
04 May 32.50 (DLQ EZ-E)	3.90	3.70	3.90	0	2,664
04 May 35.00 (DLQ EG-E)	2.25	2.20	2.30	84	16,581
04 May 37.50 (DLQ ET-E)	1.15	1.15	1.20	54	11,003
04 May 40.00 (DLQ EH-E)	0.55	0.50	0.60	8	11,819
04 May 42.50 (DLQ ES-E)	0.15	0.20	0.25	0	3,187
04 May 45.00 (DLQ EI-E)	0.10	0.05	0.10	0	183
04 Aug 20.00 (DLY HD-E)	0.00	15.20	15.30	0	0
04 Aug 22.50 (DLQ HX-E)	0.00	12.80	12.90	0	10
04 Aug 25.00 (DLQ HE-E)	10.10	10.40	10.60	0	18
04 Aug 27.50 (DLQ HY-E)	7.60	8.20	8.30	0	110
04 Aug 30.00 (DLQ HF-E)	6.30	6.20	6.30	0	71
04 Aug 32.50 (DLQ HZ-E)	4.40	4.40	4.50	0	221
04 Aug 35.00 (DLQ HG-E)	2.95	2.90	3.00	8	823
04 Aug 37.50 (DLQ HT-E)	1.70	1.75	1.85	104	365
04 Aug 40.00 (DLQ HH-E)	1.00	1.00	1.05	38	213
04 Aug 42.50 (DLQ HS-E)	0.00	0.50	0.60	0	207
04 Aug 45.00 (DLQ HI-E)	0.00	0.25	0.30	0	6
Total				6,240	552,764

TABLE 11.2A (Continued)

Puts	Last Sale	Bid	Ask	Vol	Open Int
04 Jan 5.00 (DLY MA-E)	0.05	0.00	0.05	0	245
04 Jan 7.50 (DLY MU-E)	0.45	0.00	0.05	0	1,012
04 Jan 10.00 (DLY MB-E)	0.05	0.00	0.05	0	12,981
04 Jan 12.50 (DLY MV-E)	0.05	0.00	0.05	0	1,209
04 Jan 15.00 (DLY MC-E)	0.05	0.00	0.05	0	7,190
04 Jan 17.50 (DLY MW-E)	0.10	0.00	0.05	0	9,807
04 Jan 20.00 (DLY MD-E)	0.05	0.00	0.05	0	27,524
04 Jan 22.50 (DLQ MX-E)	0.05	0.00	0.05	0	7,753
04 Jan 25.00 (DLQ ME-E)	0.05	0.00	0.05	0	23,350
04 Jan 27.50 (DLQ MY-E)	0.05	0.00	0.05	0	21,488
04 Jan 30.00 (DLQ MF-E)	0.05	0.00	0.05	0	39,133
04 Jan 32.50 (DLQ MZ-E)	0.05	0.00	0.10	70	34,591
04 Jan 35.00 (DLQ MG-E)	0.55	0.45	0.55	485	39,290
04 Jan 37.50 (DLQ MT-E)	2.55	2.40	2.50	10	4,404
04 Jan 40.00 (DLQ MH-E)	5.10	4.90	5.00	0	6,914
04 Jan 42.50 (DLQ MS-E)	0.00	7.40	7.50	0	147
04 Jan 45.00 (DLQ MI-E)	10.50	9.90	10.00	0	149
04 Jan 50.00 (DLQ MJ-E)	14.20	14.90	15.00	0	168
04 Feb 20.00 (DLY ND-E)	0.05	0.00	0.05	0	45
04 Feb 22.50 (DLQ NX-E)	0.05	0.00	0.05	0	620
04 Feb 25.00 (DLQ NE-E)	0.05	0.00	0.05	0	3,275
04 Feb 27.50 (DLQ NY-E)	0.10	0.05	0.10	0	3,721
04 Feb 30.00 (DLQ NF-E)	0.15	0.10	0.20	200	7,054
04 Feb 32.50 (DLQ NZ-E)	0.50	0.40	0.45	15	18,014
04 Feb 35.00 (DLQ NG-E)	1.25	1.20	1.30	265	10,863
04 Feb 37.50 (DLQ NT-E)	3.00	2.75	2.85	20	2,117
04 Feb 40.00 (DLQ NH-E)	5.80	4.90	5.10	0	1,051
04 Feb 42.50 (DLQ NS-E)	7.90	7.40	7.50	0	32
04 Feb 45.00 (DLQ NI-E)	10.50	9.90	10.00	0	97
04 May 20.00 (DLY QD-E)	0.00	0.00	0.05	0	0
04 May 22.50 (DLQ QX-E)	0.15	0.05	0.10	0	670
04 May 25.00 (DLQ QE-E)	0.20	0.10	0.15	0	1,252
04 May 27.50 (DLQ QY-E)	0.35	0.25	0.30	0	1,959
04 May 30.00 (DLQ QF-E)	0.55	0.50	0.60	0	11,585
04 May 32.50 (DLQ QZ-E)	1.10	1.05	1.15	50	7,858
04 May 35.00 (DLQ QG-E)	2.10	2.00	2.05	0	6,313
04 May 37.50 (DLQ QT-E)	3.20	3.40	3.50	40	893
04 May 40.00 (DLQ QH-E)	5.70	5.30	5.40	0	910
04 May 42.50 (DLQ QS-E)	0.00	7.50	7.60	0	1,155
04 May 45.00 (DLQ QI-E)	0.00	9.90	10.00	0	380
04 Aug 20.00 (DLY TD-E)	0.00	0.05	0.10	0	0
04 Aug 22.50 (DLQ TX-E)	0.00	0.10	0.20	0	0
04 Aug 25.00 (DLQ TE-E)	0.00	0.25	0.35	0	29
04 Aug 27.50 (DLQ TY-E)	0.65	0.50	0.60	0	55
04 Aug 30.00 (DLQ TF-E)	1.00	0.90	1.05	0	339
04 Aug 32.50 (DLQ TZ-E)	1.60	1.60	1.70	100	611
04 Aug 35.00 (DLQ TG-E)	2.70	2.60	2.70	0	1,153
04 Aug 37.50 (DLQ TT-E)	4.20	4.00	4.10	110	141
04 Aug 40.00 (DLQ TH-E)	0.00	5.70	5.80	0	121
04 Aug 42.50 (DLQ TS-E)	0.00	7.70	7.90	0	1
04 Aug 45.00 (DLQ TI-E)	0.00	10.00	10.10	0	0
Total				1,365	319,669

TABLE 11.2B Summary of price, volume, and open interest information for Dell leaps drawn from www.cboe.com at 1:53 PM on January 6, 2004. Underlying stock has contemporaneous bid (ask) price of 35.05 (35.06).

Calls	Last Sale	Bid	Ask	Vol	Open Int	Puts	Last Sale	Bid	Ask	Vol	Open Int
05 Jan 5.00 (ZDE AA-E)	29.30	30.00	30.20	0	237	05 Jan 5.00 (ZDE MA-E)	0.00	0.00	0.15	0	0
05 Jan 10.00 (ZDE AB-E)	25.30	25.10	25.30	0	1,000	05 Jan 10.00 (ZDE MB-E)	0.05	0.00	0.15	0	1,316
05 Jan 15.00 (ZDE AC-E)	17.90	20.20	20.40	0	1,464	05 Jan 15.00 (ZDE MC-E)	0.10	0.00	0.15	0	4,597
05 Jan 17.50 (ZDE AW-E)	18.70	17.80	18.00	0	570	05 Jan 17.50 (ZDE MW-E)	0.20	0.05	0.15	0	1,044
05 Jan 20.00 (ZDE AD-E)	13.70	15.40	15.60	0	5,759	05 Jan 20.00 (ZDE MD-E)	0.25	0.15	0.25	0	4,618
05 Jan 22.50 (ZDE AX-E)	11.90	13.10	13.30	0	3,021	05 Jan 22.50 (ZDE MX-E)	0.60	0.30	0.40	0	6,358
05 Jan 25.00 (ZDE AE-E)	11.00	10.90	11.10	0	6,291	05 Jan 25.00 (ZDE ME-E)	0.65	0.60	0.70	50	7,969
05 Jan 27.50 (ZDE AY-E)	8.20	8.90	9.00	0	11,869	05 Jan 27.50 (ZDE MY-E)	1.00	1.00	1.10	0	4,784
05 Jan 30.00 (ZDE AF-E)	6.40	7.00	7.20	0	18,903	05 Jan 30.00 (ZDE MF-E)	1.75	1.60	1.70	0	7,978
05 Jan 32.50 (ZDE AZ-E)	5.50	5.30	5.50	6	9,914	05 Jan 32.50 (ZDE MZ-E)	2.65	2.35	2.50	0	6,032
05 Jan 35.00 (ZDE AG-E)	4.00	3.90	4.10	13	47,104	05 Jan 35.00 (ZDE MG-E)	3.60	3.40	3.60	0	16,575
05 Jan 37.50 (ZDE AT-E)	2.90	2.80	2.90	76	8,299	05 Jan 37.50 (ZDE MT-E)	5.10	4.80	5.00	0	1,605
05 Jan 40.00 (ZDE AH-E)	1.90	1.90	2.00	72	19,980	05 Jan 40.00 (ZDE MH-E)	6.50	6.40	6.60	0	3,127
05 Jan 42.50 (ZDE AS-E)	1.35	1.25	1.35	50	2,990	05 Jan 42.50 (ZDE MS-E)	8.90	8.20	8.40	0	1,418
05 Jan 45.00 (ZDE AI-E)	0.75	0.80	0.90	0	7,157	05 Jan 45.00 (ZDE MI-E)	12.30	10.30	10.50	0	1,132
05 Jan 50.00 (ZDE AJ-E)	0.35	0.30	0.40	150	4,766	05 Jan 50.00 (ZDE MJ-E)	15.60	14.90	15.00	0	2,833
06 Jan 20.00 (WDQ AD-E)	16.40	16.20	16.40	0	1,078	06 Jan 20.00 (WDQ MD-E)	0.55	0.55	0.65	0	426
06 Jan 22.50 (WDQ AX-E)	0.00	14.10	14.40	0	220	06 Jan 22.50 (WDQ MX-E)	0.95	0.90	1.00	0	391
06 Jan 25.00 (WDQ AE-E)	12.30	12.20	12.40	10	543	06 Jan 25.00 (WDQ ME-E)	1.50	1.35	1.45	0	311
06 Jan 27.50 (WDQ AY-E)	10.80	10.40	10.60	0	642	06 Jan 27.50 (WDQ MY-E)	2.40	1.95	2.05	0	476
06 Jan 30.00 (WDQ AF-E)	8.50	8.70	9.00	0	1,310	06 Jan 30.00 (WDQ MF-E)	2.80	2.70	2.80	20	1,249
06 Jan 32.50 (WDQ AZ-E)	6.70	7.20	7.50	0	674	06 Jan 32.50 (WDQ MZ-E)	3.80	3.60	3.80	0	5,498
06 Jan 35.00 (WDQ AG-E)	5.50	5.90	6.10	0	7,414	06 Jan 35.00 (WDQ MG-E)	5.40	4.80	4.90	0	8,683
06 Jan 37.50 (WDQ AT-E)	4.40	4.80	5.00	0	369	06 Jan 37.50 (WDQ MT-E)	7.10	6.10	6.20	0	4,621
06 Jan 40.00 (WDQ AH-E)	3.40	3.80	4.00	0	3,826	06 Jan 40.00 (WDQ MH-E)	9.40	7.50	7.80	0	834
06 Jan 42.50 (WDQ AS-E)	2.55	2.95	3.10	0	801	06 Jan 42.50 (WDQ MS-E)	0.00	9.20	9.50	0	695
06 Jan 45.00 (WDQ AI-E)	2.10	2.30	2.45	0	1,642	06 Jan 45.00 (WDQ MI-E)	11.10	11.10	11.30	0	1,911
06 Jan 50.00 (WDQ AJ-E)	1.35	1.30	1.50	0	1,387	06 Jan 50.00 (WDQ MJ-E)	15.10	15.20	15.40	0	1,188
Total				377	169,230					70	97,669

In Table 11.2A, Dell stock options have exercise prices ranging up to 45. As a matter of policy, the exchange lists options with at least two exercise prices on each side of the current stock price. With the current stock price about $35, this means that exercise prices of 25, 30, 40 and 45 should appear, and they do. Where a wider range of exercise prices appear (such as in the case for Dell options on January 6, 2004), it may be (1) a reflection of a large stock price move during the life of the option or (2) that a specific exercise price was requested by a customer.

Table 11.2A reveals two interesting characteristics about stock option markets. First, at-the-money options tend to be the most active. Table 11.2A shows that more than 99% of call option trading volume and 85% of put option trading volume on January 6, 2004 was in option series with exercise prices between 32.50 and 37.50 (i.e., at-the-money options). Second, the total open interest for calls, 552,764, exceeds that of puts, 319,669. In stock option markets, there seems to be greater interest in speculating that the stock price will rise rather than fall. In the next chapter, we find the opposite pattern for stock index options. In that market, the demand for portfolio interest causes the open interest of puts to be significantly greater than for calls.

Table 11.2B has the same columns as Table 11.2A. The only difference is that Table 11.2B contains leaps written on Dell's stock. As noted earlier, leaps have January expirations. As of January 6, 2004, Dell had leaps expiring in January 2005 and January 2006. When Dell's January 2004 stock options expire on January 17, 2004, leaps with a January 2007 expiration will be introduced. Note that there is significant open interest in long-term options. Apparently a large number of traders have long-term directional views on Dell's stock price.

Equity FLEX Options The stock option exchanges also facilitate trading of stock options with nonstandard terms. Called "FLEX options," these contracts are tailor-made to suit a customer's needs. The contract can be a call or a put, American-style or European-style, and as long as three years to expiration. For puts, exercise prices may be set in 1/8 increments. For calls, exercise prices are limited to the minimum strike price intervals that are available for the non-FLEX stock options. Like standard stock options, FLEX options call for the delivery of the underlying stocks on expiration day.

VALUATION

Valuing derivatives contracts written on common stocks follows the principles developed for the case where the underlying asset has discrete cash disbursements (i.e., cash dividends) during the life of the contract. All of the valuation principles are summarized in Table 11.3. Before applying these principles, however, the procedural aspects of cash dividend payments for U.S. firms are discussed. In addition, we provide a general sense for the number of U.S. firms that pay dividends vis-à-vis the firms that do not.

TABLE 11.3 Summary of arbitrage price relations and valuation equations/methods for derivatives on common stocks.

Arbitrage Relations

Forward/Futures

$$f = F = Se^{rT} - FVD \text{ or } fe^{-rT} = Fe^{-rT} = S - PVD$$

where

$$FVD = \sum_{i=1}^{n} D_i e^{r(T-t_i)} \text{ and } PVD = e^{-rT}FVD = \sum_{i=1}^{n} D_i e^{-rt_i}$$

European-Style:	**Options**	**Futures Options**
Lower bound for call	$c \geq \max(0, S - PVD - Xe^{-rT})$	$c \geq \max[0, e^{-rT}(F - X)]$
Lower bound for put	$p \geq \max(0, Xe^{-rT} - S + PVD)$	$p \geq \max[0, e^{-rT}(X - F)]$
Put-call parity	$c - p = S - PVD - Xe^{-rT}$	$c - p = e^{-rT}(F - X)$
American-Style:	**Options**	**Futures Options**
Lower bound for call	$C \geq \max(0, S - PVD - Xe^{-rT}, S - X)$	$C \geq \max(0, F - X)$
Lower bound for put	$P \geq \max(0, Xe^{-rT} - S + PVD, X - S)$	$P \geq \max(0, X - F)$
Put-call parity	$S - PVD - X \leq C - P \leq S - PVD - Xe^{-rT}$	$Fe^{-rT} - X \leq C - P \leq F - Xe^{-rT}$

Valuation Equations/Methods

European-Style:	**Options**	**Futures Options**
Call value	$c = S^x N(d_1) - Xe^{-rT}N(d_2)$	$c = e^{-rT}[FN(d_1) - XN(d_2)]$
Put value	$p = Xe^{-rT}N(-d_2) - S^x N(-d_1)$	$p = e^{-rT}[XN(-d_2) - FN(-d_1)]$
	where $S_x = S - PVD$	where
	$d_1 = \dfrac{\ln(S^x/X) + (r + 0.5\sigma^2)T}{\sigma\sqrt{T}}$	$d_1 = \dfrac{\ln(F/X) + 0.5\sigma^2 T}{\sigma\sqrt{T}}$
	and $d_2 = d_1 - \sigma\sqrt{T}$	and $d_2 = d_1 - \sigma\sqrt{T}$
American-Style:	**Options**	**Futures Options**
Call and put values	Numerical valuation: binomial and trinomial methods	Numerical valuation: quadratic approximation, binomial method, and trinomial method

Discrete Cash Dividend Payments

Cash dividends on U.S. stocks are generally paid on a quarterly basis. A firm's board of directors meets each quarter and makes the announcement. The announcement date is called the *dividend declaration date*. The announcement identifies: (1) who will get the dividend; (2) how much the dividend will be; and (3) when the dividend will be paid (i.e., the *dividend payment date*). The shareholders to receive the dividend are those holding shares on a particular date called the *shareholder record date*. Because stocks have delayed settlement, you must buy the stock prior to the record date in order to receive the dividend. Settlement is three business days. The *ex-dividend date* is the day the stock first begins trading without the escrowed dividend embedded in its price. If you buy the stock on the ex-dividend date or later, you will not be a shareholder of record by the shareholder record date and hence will not receive dividend.

The number of days between these dates varies across stocks. Figure 11.2 gives a sense of what might be typical. The figure contains the median number of days between (1) the declaration date and the ex-dividend date, (2) the ex-dividend date and the shareholder record date, and (3) the shareholder record date and the dividend payment date for all NYSE/AMEX and NASDAQ stocks paying quarterly dividends in the years 1996 through 2000. The stocks included are only those that had options listed on the CBOE during that period. As the figure shows, the amount of the cash dividend and the dividend payment date are typically known at least 32 days beforehand. For the valuation of short-term term stock options, this means that assuming that the amount and the timing of the dividend payment are *known* is literally true.

For longer-term options with multiple expected dividends paid during the option's life, cash dividend estimation becomes necessary. A casual inspection of cash dividend histories, however, will show that firms tend to: (1) pay the same cash dividend each quarter throughout the year; (2) pay the quarterly dividends at the same times each year; and (3) increase the annual total cash dividends at a constant rate through time. Even in the case of valuing longer-term stock options, therefore, using an assumption that the amount and timing of cash dividend payments are known is reasonable. The amount of the *i*th cash dividend will be denoted D_i and the time to the payment of the *i*th dividend is t_i, where the relevant dividends for option valuation purposes are those prior to the option's expiration, $t_i < T$ for all i. We drop the subscript i for cases in which only one dividend is paid during the option's life.

Finally, it is useful to have some general understanding of the number of stocks that pay dividends. Table 11.4 summarizes the number of U.S. stocks that pay dividends vis-à-vis those that do not. The numbers were generated from a listing of all stocks that had options listed on the CBOE during the five-year period 1996 through 2000. The total number of stocks is 2,387. Of these, less than 25% pay dividends. NYSE/AMEX stocks have a higher rate of dividend payment (about 47% of all stocks) than NASDAQ (less than 6% of all stocks). In other words, for the vast majority of stocks with options traded on a U.S. exchange, the underlying stock pays no dividends.

FIGURE 11.2 Median number of calendar days between quarterly dividend dates for NYSE/AMEX and NASDAQ stocks during the calendar year 2003.

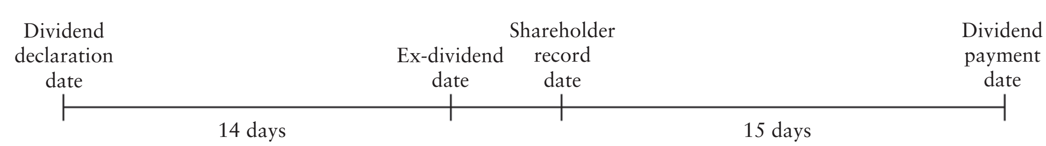


TABLE 11.4 Number of dividend-paying/nondividend-paying stocks with listed options during calendar year 2003.

Number of Stocks	**NYSE/AMEX**	**NASDAQ**	**Both**
Pays dividends	693	104	797
No dividends	717	981	1,698
Total	1,410	1,085	2,495

Proportion of Total	**NYSE/AMEX**	**NASDAQ**	**Both**
Pays dividends	27.8%	4.2%	31.9%
No dividends	28.7%	39.3%	68.1%
Total	56.5%	43.5%	100.0%

Forwards/Futures

The net cost of carry relation for a futures contract written on a common stock is

$$F = Se^{rT} - FVD \tag{11.1a}$$

or

$$Fe^{-rT} = S - PVD \tag{11.1b}$$

where

$$FVD = \sum_{i=1}^{n} D_i e^{r(T-t_i)}$$

is the future value of the cash dividends paid during the futures life and

$$PVD = FVDe^{-rT} = \sum_{i=1}^{n} D_i e^{-rt_i}$$

is the present value of the cash dividends. The relation arises from the absence of costless arbitrage opportunities in the marketplace. The intuition for this relation is that there are two ways to have the stock on hand at time T at a price known today. The first, represented by the left-hand side of (11.1a), is to buy a futures contract with maturity T. At time T, you pay F and receive the stock. The second, represented by the right-hand side of (11.1a), is to borrow at a rate r to buy the stock today, and then carry it until T has elapsed. At time T, you must repay your borrowings plus interest, Se^{rT}, which is partially offset by the quarterly cash dividends (plus accrued interest) you received while holding the stock, FVD. Since you are indifferent between the two alternatives, the two sides of (11.1a) must be equal.

ILLUSTRATION 11.1 Value of stock futures contract.

Futures contracts on Australian stocks are listed on the Sydney Futures Exchange (SFE). Compute the value of a four-month futures contract on the shares of Foster Brewing. Assume the current share price is AD 27, the risk-free rate of interest is 5.75%, and the Foster's will pay a cash dividend of AD 0.25/share in exactly three months. The denomination of the SFE stock futures is 1,000 shares.

Substituting into the cost of carry relation, you get

$$F = 27e^{(0.0575)(4/12)} - 0.25e^{0.0575(4/12 - 3/12)} = 27.271$$

The value of the futures contract is AD 27.271.

Options: No-Arbitrage Price Relations

The arbitrage relations for common stock options are also summarized in the first panel of Table 11.3. For the options written directly on the stock (rather than on a stock futures), the relation usually involves reducing the current stock price, S, by the present value of the dividends paid during the option's life, PVD. The arbitrage transactions supporting each of these relations were described in detail in Chapter 4. Consequently, they are not rederived here. Instead, two of the relations are illustrated numerically.

ILLUSTRATION 11.2 Compute lower price bound of leap.

Compute the lower price bound of a three-year, European-style call option with an exercise price of 100. The current share price is 90. The stock is expected to pay quarterly cash dividend of \$.50 per share in three months, with each subsequent dividend growing at a continuous rate of 2% annually. The risk-free rate of interest on a three-year discount bond is 5.90%. The denomination of the leap contract is 100 shares.

The present value of the cash dividends paid during the option's life is

$$PVD = \sum_{i=1}^{12} 0.50e^{-0.0590(i/4)}e^{0.02(i-1)/4} = 5.6066$$

The easiest way to compute this value is to use a spreadsheet such as that shown below. The lower price bound of the call is therefore

$$S - PVD - Xe^{-rT} = 90 - 5.6066 - 83.7780 = 0.6154$$

so the lower price bound on the leap contract is \$61.54.

Lower Price Bound for European-Style Call on a Common Stock					
		Quarterly Dividends			
Stock Price (S)	**90**	i	t_i	D_i	$PV(D_i)$
Interest rate (r)	5.90%	1	0.25	0.5000	0.4927
Current dividend (D)	0.5000	2	0.50	0.5025	0.4879
Dividend growth (g)	2.00%	3	0.75	0.5050	0.4832
		4	1.00	0.5076	0.4785
Exercise price (X)	100	5	1.25	0.5101	0.4738
Years to expiration (T)	3.00	6	1.50	0.5127	0.4692
Denomination (N)	100	7	1.75	0.5152	0.4647
		8	2.00	0.5178	0.4602
PVD	5.6066	9	2.25	0.5204	0.4557
Xe^{-rT}	83.7780	10	2.50	0.5230	0.4513
$S - PVD - Xe^{-rT}$	0.6154	11	2.75	0.5256	0.4469
$(S - PVD - Xe^{-rT})N$	61.54	12	3.00	0.5283	0.4426

Options: Valuation Equations/Methods

The valuation equations/methods for common stock options are summarized in the second panel of Table 11.3. Below are two illustrations, one for European-style option valuation and one for American-style option valuation.

European-Style Option Valuation As was noted earlier in the chapter, all exchange-traded stock options listed in the United States are American-style. Where the underlying stock pays no dividends during the option's life, the American-style call will not optimally be exercised prior to expiration, and, hence, can be valued using the European-style valuation equation.

ILLUSTRATION 11.3 Compute implied volatilities from call option prices.

Compute the implied volatilities of the Feb-04 Dell call options with exercise prices 32.50, 35, and 37.50 using the bid and ask price quotes reported in Table 11.2a. Assume Dell's share price is $35.055. Dell does not pay cash dividends, and the risk-free interest rate is 0.82%.

To compute the implied volatilities, you need all terms of the option valuation formula except σ. The stock price midpoint is 35.055, the exercise prices are given in the table, and the risk-free rate is 0.82%. The option contract month is February 2004. Stock options, by convention, expire the Saturday after the third Friday of the contract month, so, looking at a calendar, this means that the effective expiration date is the close of trading on Friday, February 20, 2004 (the option market is not open on Saturday). The times to expiration of the Feb-04 options are, therefore, 45 days.

Using the bid price quote, the implied volatility for the call with an exercise price of 32.50 may be computed by solving

$$3.00 = 35.055N(d_1) - 32.50e^{-0.0082(45/365)}N(d_2)$$

where

$$d_1 = \frac{\ln(35.055e^{0.0082(45/365)}/32.50) + 0.5\sigma^2(45/365)}{\sigma\sqrt{45/365}}$$

and $d_2 = d_1 - \sigma\sqrt{45/365}$.

The solution is found iteratively and is 27.99%.[11] For the remaining calls and price quotes, the implied volatilities are:

DELL Call Option-Implied Volatilities

Valuation date	1/6/2004
Expiration date	2/20/2004
Days to expiration	45
Interest rate	0.820%
Stock price midpoint	35.055

	Quotes		Implied Volatilities	
Exercise Price	Bid	Ask	Bid	Ask
32.50	3.00	3.10	27.99%	30.78%
35.00	1.30	1.40	25.59%	27.63%
37.50	0.35	0.45	23.33%	25.98%

Note that the bid/ask spread, when translated into an implied volatility spread is quite large. For the call option with the 32.50 exercise price, for example, the spread is 2.79%. Also, note that the implied volatilities at the bid (or at the ask) are not the same across exercise prices. There may be a variety of reasons for this. First, price quotes are rounded to the nearest $.05. As already noted, small differences in price translate into large differences in implied volatility. Second, computing implied volatilities using the BSM model presumes that Dell's share price is log-normally distributed at the options' expiration. To the extent that it is not, you can expect to see systematic variation in implied volatilities. Third, to the extent that traders focus on particular option series, prices (and hence implied volatilities) may be affected by supply/demand imbalances. In order to bring the implied volatilities into alignment, a dynamic hedge would be necessary. The costs of such a hedge over the life of the option may exceed the profit from an apparent arbitrage opportunity.

American-Style Option Valuation Table 11.3 summarizes the recommended methods for valuing American-style stock options. For options written on stock futures, all of the techniques described in Chapter 9 work well. For options written on dividend-paying stocks directly, however, using a lattice-based procedure is best. This section uses modifying the binomial method to value both American-style calls and puts on stocks with multiple known dividends during the option's life.

Generally speaking, the most expedient methods for valuing American-style options on dividend-paying stocks are the binomial and trinomial methods. The

[11] The function, OV_OPTION_ISD, from the OPTVAL Function Library can be used to compute implied volatility.

mechanics of these procedures are contained in Chapter 9. There are two exceptions, however. The first is where the stock's dividends are "small." If all the anticipated dividends paid during the call's life satisfy (6.16) in Chapter 6, for example, there is no chance that the American-style call will be exercised early, so the value of the call can be computed exactly using the European-style call formula. The second is where only a single dividend is paid during the call's life. In this case, an analytical valuation formula exists,[12] and it is provided in Appendix 11.A to this chapter. This formula can also be extended to cases where two or more dividends are paid during the option's life, however, the formula becomes cumbersome and difficult to evaluate, and the lattice-based methods wind up being more computationally efficient.[13]

ILLUSTRATION 11.4 Compute value of American-style put option.

Compute the value of an American-style put option with an exercise price of \$50 and a time to expiration of 90 days. Assume that the risk-free rate of interest is 5% annually, that the stock price is \$50, that the volatility rate of the stock is 36% per year, and that the stock pays a dividend of \$2 in exactly 75 days.

For pedagogic reasons, perform three different valuations.

1. Compute the European-style put option value using the analytical valuation equation in Table 11.3.
2. Compute the European-style put option value using the JR binomial method outlined in Chapter 9.
3. Compute the American-style put option value using the JR binomial method.

By doing so, you not only value the American-style put option but also identify the degree of error that we might expect in our binomial approximation.

1. In applying the European-style put formula, it is first necessary to compute the current stock price net of the present value of the promised dividend, that is,

$$S^x = 50 - 2e^{-0.05(75/365)} = 48.020$$

With the adjusted stock price in hand, we apply the valuation formula from Table 11.3, that is,

$$p = 50e^{-0.05(90/365)}N(-d_2) - 48.020N(-d_1)$$

where

$$d_1 = \frac{\ln(48.020e^{0.05(90/365)}/50) + 0.5(0.36^2)(90/365)}{0.36\sqrt{90/365}} = -0.0677$$

The probabilities $N(0.0677)$ and $N(0.2464)$ are 0.5270 and 0.5973, respectively, so the European-style put value is

$$p = 49.387(0.5973) - 48.020(0.5270) = 4.195$$

[12] See Roll (1977), Geske (1979), and Whaley (1981).
[13] See Stephan and Whaley (1990).

This computation can be verified using the OPTVAL function

OV_ OPTION_VALUE (48.020, 50,90/365, 0.05, 0.36, “C”, “E”) = 4.195

2. The value of the European-style put is also computed using the binomial method. Apply the three-step procedure outlined in Chapter 9. The number of time steps is set equal to 90, so the time increment Δt is one day or 0.00274 years. Under the JR binomial method, the values of the up-step and down-step coefficients are computed as

$$u = e^{(b - 0.5\sigma^2)\Delta t + 0.36\sqrt{\Delta t}} = e^{(0.05 - 0.5(0.36)^2)(1/365) + 0.36\sqrt{1/365}} = 1.01898$$

and

$$d = e^{(0.05 - 0.5(0.36)^2)(1/365) - 0.36\sqrt{1/365}} = 0.98129$$

and there are equal probabilities of an up-step and a down-step.[14] Applying the up-step and down-step coefficients to the current stock price net of the present value of the escrowed dividend provides a range of stock prices at the option’s expiration from 8.776 to 260.828. Applying the binomial procedure without checking the early exercise bounds produces an option value of 4.195, the same as the value obtained using the analytical formula. Apparently, the binomial method works well at 90 times step.

The OPTVAL Function Library contains binomial and trinomial routines for valuing European- and American-style options on dividend-paying stocks. The syntax of the function call for the binomial method is

OV_STOCK_OPTION_VALUE_BIN(*s, x, t, r, v, n, cp, ae, mthd, dvd, tdvd*)

where *s* is the current stock price, *x* is the exercise price, *t* is the time to expiration, *r* is the risk-free interest rate, *v* is the stock’s volatility rate, *cp* is a (c)all/(p)ut indicator, *ae* is an (A)merican/(E)uropean-style option indicator, *mthd* is the choice of binomial coefficients (2 is JR coefficients),[15] *dvd* is a cash dividend vector, and *tdvd* is a vector containing the time to the dividend payments. For the information in the problem:

D15 =OV_STOCK_OPTION_VALUE_BIN(B3,B11,B13,B16,B4,D11,"p","e",2,B5,B7)

	A	B	C	D
1	**Stock option valuation using the binomial method**			
2	***Stock***		***Intermediate computations***	
3	Price (*S*)	50.00	Time to expiration in years (*T*)	0.2466
4	Volatility rate (*σ*)	36.00%	Time to ex-dividend in years (*t*)	0.2055
5	Amount (*D*)	2.00	*PVD*	1.980
6	Time to ex-dividend in days	75	*S-PVD*	48.020
7	Years to ex-dividend	0.2055		
8				
9	***Option***			
10	Call (*C*) or put (*P*)	*P*	***Binomial parameters***	
11	Exercise price (*X*)	50	No. of time steps (*n*)	90
12	Days to expiration	90		
13	Years to expiration	0.2466	***Option value***	
14			European, analytic	4.195
15	***Market***		European, binomial	4.195
16	Interest rate (*r*)	5.00%	American, binomial	4.234

[14] In this application, the risk-neutral net cost of carry rate, *b*, in (9.12a) and (9.12a) of Chapter 9 equals the risk-free rate of interest.

[15] Chapter 9 contains a description of three sets of coefficients that may be used in the binomial method.

3. The binomial procedure applied to value the European-style put is reapplied, this time checking the early exercise bounds at each node within the lattice. The value of the American-style put is computed to be 4.234. Hence the value of the early exercise feature of this American-style put is 4.234 – 4.195 or about 3.9 cents. The previous table summarizes the results.

Options: Implied Volatilities in Days Surrounding Merger Events

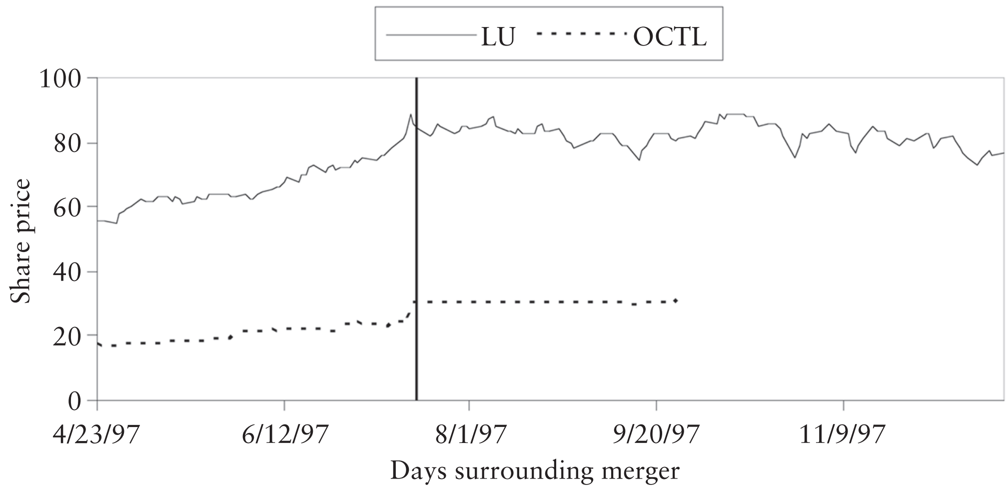
Implied volatilities were introduced in Chapter 7. By setting an option's observed price equal to its model value, we can deduce the market's perception of expected future volatility in the same manner as setting a bond's price equal to its formula value allows us to deduce the expected yield to maturity. In the context of the stock option valuation models described earlier in this section, the implied volatilities of options on a particular stock should be approximately the same across exercise prices and constant through time. In certain instances, however, such is not the case. One such instance is when a firm becomes a target in a takeover attempt. Below we describe the behavior of stock prices, trading volumes, and volatilities in the days surrounding Lucent Technologies' acquisition of Octel Communications in 1997.

Just before the market open on Thursday, July 17, 1997, Lucent Technologies, Inc. (LU) announced that it would acquire Octel Communications Corp. (OCTL) in order to strengthen its voice mail, fax, and messaging technology business. Under the terms of the offer, Lucent agreed to pay $31 per share in cash. The LU/OCTL merger was less complicated than most in the sense that it was a cash deal, with both boards approving the deal before its announcement.[16] To examine the market's reaction to the news of the merger, we focus on share price, trading volume, and BSM implied volatility behavior in the 60 days before the announcement and the 60 days after the announcement became effective.

Share Price Behavior Figure 11.3 shows the share prices of LU and OCTL in the days surrounding the merger. The prices of both stocks meandered in an upward direction in the days leading up to the announcement day (with the vertical bar representing the announcement day). An explanation for this behavior is that the firms' merger negotiations were being conducted during June 1997, and the market was beginning to anticipate the news. On July 16, 1997, the day before the announcement, OCTL closed at 26.75, a 14.1% gain from the previous day's close, 23.4375. The strength of the gain suggests that some traders were confident about the terms of the potential acquisition and its likelihood of success and were willing to take a directional bet by buying the shares of OCTL. The merger announcement was made just before the market open on July 17, and the price of OCTL's shares reacted accordingly. OCTL's shares closed at 30.125, a gain of another 12.6%. Subsequent to the announcement, OCTL shares hovered at slightly below the offer price of $31 per share. The lack of variability in OCTL's share price during this period suggests that the market believed that the merger would be consummated at the $31 level. The slight drop in OCTL's share price on September 11, 1997 was as a result of an

[16] See "Lucent to buy Octel for $1.8 billion," *Reuters News,* 17 July 1997.

FIGURE 11.3 Daily stock price behavior of Lucent Technologies, Inc. (LU) and Octel Communications, Inc. (OCTL) from April 23 (60 days before merger announcement date) to December 22, 1997 (60 days after merger effective date). Merger announcement date was July 17, 1997, and merger effective date was September 26, 1997.

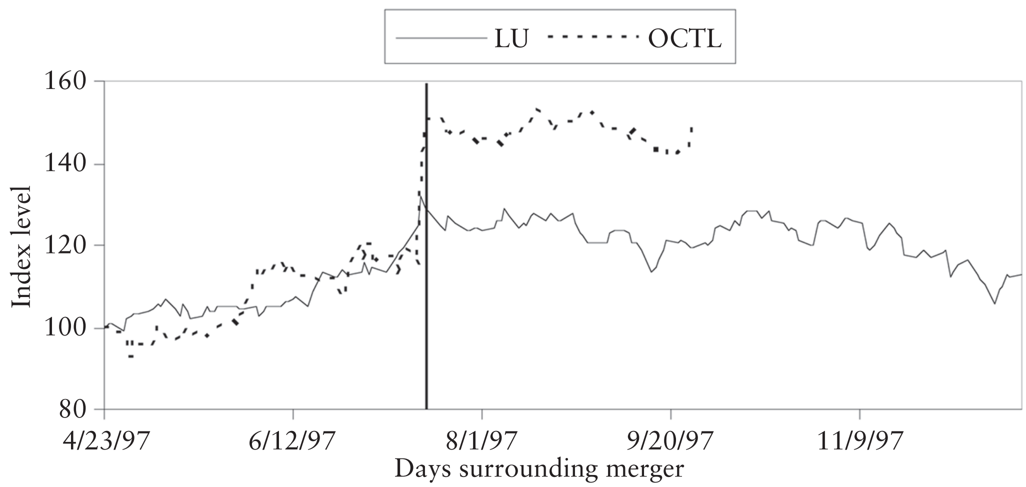


announcement that the antitrust division of U.S. Justice Department requested more information about the terms of the merger from Lucent. Included with this announcement, however, was language indicating that both companies were confident that the acquisition would be completed, as it indeed was.[17] The last day of public trading for OCTL's shares was September 26, 1997.

Abnormal Share Price Behavior The share price behavior in Figure 11.3 can be somewhat misleading to the extent that the stock prices have different scales, and the movement of the market during the period is ignored. Consequently, we standardize both price series to a beginning level of 100, and then update each price series by the daily relative stock price movement net of the corresponding market movement, using the S&P 500 index as a proxy for the market. Figure 11.4 shows the results. Relative to the S&P 500, both stocks performed well relative to the S&P 500 in the pre-announcement period, with each an posting abnormal gain of 25% or so in the 60 trading days leading up to the announcement. Again, this may have been as a result of information leakage regarding the merger negotiations. But, these abnormal gains were small relative to those experienced on the day before and the day of the announcement, 13.0% and 13.1%, respectively. Immediately after the announcement, the shares of LU or OCTL behaved similarly to the market, with both declining in the aftermath. The declines, however, were as a result of the S&P 500 index rising rather than share prices falling. (See Figure 11.3.)

[17] See "Lucent Extends Octel Tender Offer," *Newsbytes News Network,* 11 September 1997.

FIGURE 11.4 Abnormal stock price behavior of Lucent Technologies, Inc. (LU) and Octel Communications, Inc. (OCTL) from April 23 (60 days before merger announcement date) to December 22, 1997 (60 days after merger effective date). Daily abnormal stock price movements are computed by subtracting the movement of the S&P 500 index each day, and both stock price series are normalized to a level of 100 on April 23, 1997.



Trading Volume The market reaction of LU and OCTL shares to the news of the merger is also shown in trading volume. Figure 11.5 shows that in the period before the announcement, daily trading volume was about two million shares a day for LU and one million shares for OCTL. In the days leading up to the announcement, OCTL's share volume appears to have a slight increase, however, on the day before the announcement, 2.7 million shares traded, and, on the day of the announcement, a whopping 16.3 million shares traded. Similarly, LU experienced trading volume of 4.7 million shares on the day before the announcement and 4.2 million shares on the announcement day. Trading volumes remained above normal for both firms for a few days after the announcement, and then returned to preannouncement levels or below. Like price, trading volume confirms abnormal market behavior on the day before and the day of the announcement.

Implied Volatility Perhaps, the most intriguing information regarding the potential acquisition appeared in the stock option market. To do so, we examine the implied volatilities[18] of LU and OCTL stock options in the 60 days before the merger announcement and the 60 days after the merger became effective. We begin by examining OCTL volatilities. Figure 11.6 shows that, prior to July 1997, the implied volatility of two-month, at-the-money options on OCTL's stock averaged about 48%, only twice crossing the 50% level. On June 27, however, it crossed the 50% level, and then rose as high as 70% on the day

[18] The implied volatility in this case is for a hypothetical 60-day, at-the-money option. This implied volatility is computed on the basis of eight option series—the nearby and second nearby options (calls and puts) whose exercise prices are just in- and out-of-the-money.

FIGURE 11.5 Daily trading volume is shares of Lucent Technologies, Inc. (LU) and Octel Communications, Inc. (OCTL) from April 23 (60 days before merger announcement date) to December 22, 1997 (60 days after merger effective date).

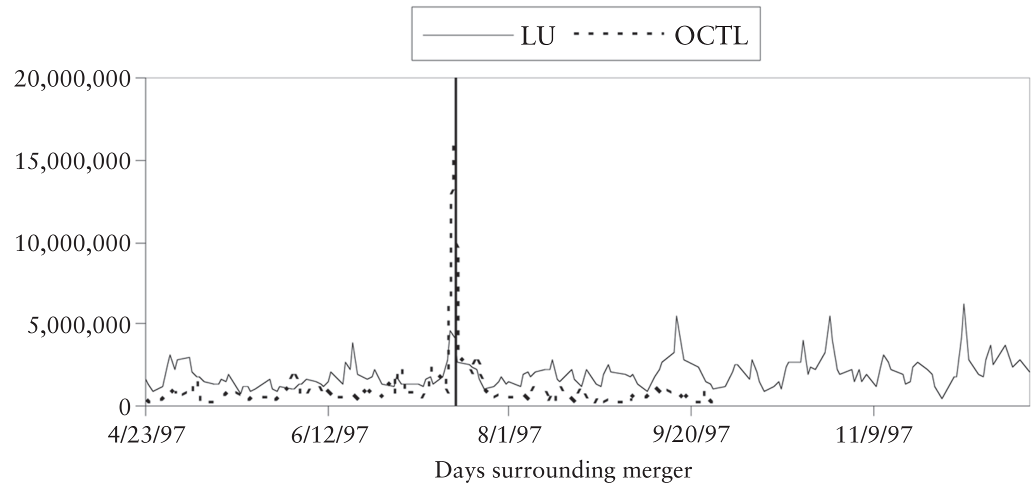
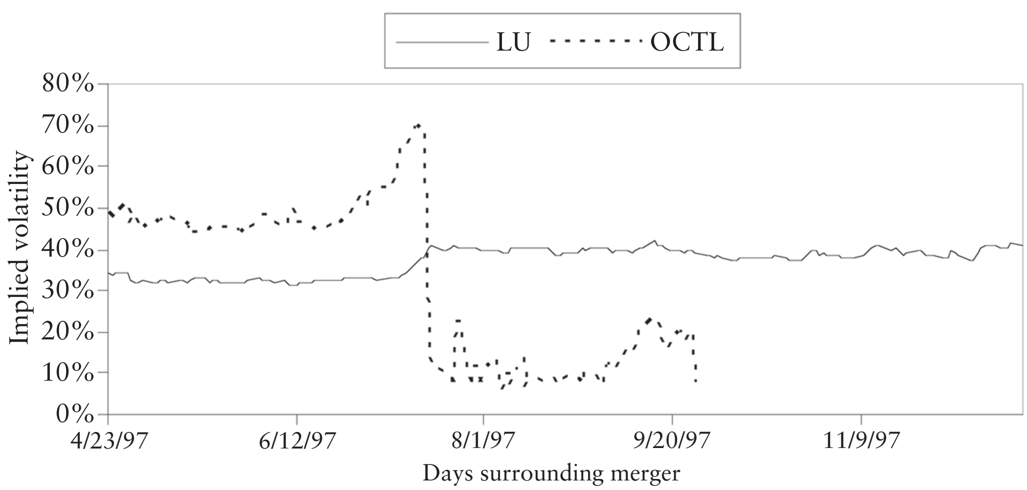


FIGURE 11.6 Average BSM implied volatilities of stock options on Lucent Technologies, Inc. (LU) and Octel Communications, Inc. (OCTL) from April 23 (60 days before merger announcement date) to December 22, 1997 (60 days after merger effective date).



before the announcement. On the announcement day, OCTL volatility plummeted from its high to a level of 13.8%. OCTL's implied volatility bottomed out in the days following, hovering around 10%. But on September 3, eight days before the announcement that more information had been requested, OCTL's implied volatility rose to 12.3%. By the close on September 11, the implied volatility rose to 20.3%, and, by the close on September 15, 23.6%.

Taken together, this evidence suggests that the stock option market anticipated news about OCTL and its impending merger before the stock market. First, almost *two weeks* before the announcement day, OCTL's implied volatility began to increase monotonically, reaching levels nearly 46% higher (70% versus 48%) than had been observed in the recent past.[19] This is in contrast to OCTL's stock price behavior, which seemed to indicate that, at best, the information leaked out the day before the announcement. Second, in the postannouncement period, OCTL's implied volatility began to rise inexplicably eight days before the announcement that the antitrust department had requested more information regarding the impending merger. The stock market did not appear to react until the day of the announcement, September 11.

On first appearance, the dramatic drop in OCTL's implied volatility on the announcement day may seem perplexing. Upon further reflection, the mystery is resolved. The OCTL option prices in the days after the announcement can be thought of as an amalgam of two prices—one if the merger falls through and one if the merger is successful, that is,

$$O_{observed} = (1 - p)O_{fall} + pO_{success} \tag{11.2}$$

where p is the probability that the merger will succeed. The option price conditional on failure, O_{fall}, may be computed using the BSM model. The option price conditional on success, $O_{success}$, equals the floor value of the option since, as noted earlier, the options will be settled in cash and should be exercised immediately when the merger is consummated. The dramatic reduction in OCTL's implied volatility (based on the observed option price) is therefore merely a reflection that the market anticipated that the probability of the merger succeeding was very high. It is also interesting to note that the probability that the merger will fail never completely disappears. Even on the day before the merger becoming effective, the OCTL implied volatility is nearly 8%, which implies that $p < 1$ in (11.2).

The behavior of the implied volatility of LU's shares is also intriguing. Up until a week before the merger announcement, its level was about 32%. On July 10, it began to rise, and, on July 17, it appears to have reached a new steady level of about 40%. These results are interesting in at least two respects. First, again the stock option market appears to have anticipated the news about the merger before the stock market—implied volatilities move before stock prices. One possibility is that "informed" investors choose the option market rather than the stock market to place directional bets. Another is the number of informed traders in each market before the announcement is the same, but, since the stock option market is less liquid, the same size stock equivalent trade has greater price impact (and is more detectible) in the option market than the stock market. Second, the market appears to digest the news about the merger very quickly in that the implied volatility embedded in LU's options rises to its new steady-state level on the announcement day. In other words, the option market incorporated the effect

[19] It is important to recognize that the implied volatility is based on call and put prices. An increase in implied volatility is not based on the call price rising faster than the stock price (i.e., the stock price being too low) but rather on the prices of the call and put rising relative to the stock price.

of the change LU's asset structure (replacing $1.8 billion in cash with OCTL's assets) on LU's return volatility well before the merger became effective.

TRADING AND RISK MANAGEMENT STRATEGIES

Stock derivatives contracts can be used in a variety of trading/risk management strategies, many of which were discussed in Chapter 10. The purpose of this section is to describe the motivation for and execution of four commonly used strategies involving stock derivatives. The first strategy is a speculative trading strategy called a dividend spread and is designed to capture abnormal profit when American-style call option holders do not exercise early when it is in their best interests to do so. The second and third are risk management strategies used by individuals with concentrated positions in particular stocks. We examine both stock price collars and variable prepaid forward contracts. The fourth and final strategy, used by corporations, involves writing puts (and selling calls) to subsidize the cost of stock buyback programs.

Dividend Spreads

In spite of the fact that it is straightforward to decide if and when an American-style option should be exercised early, many are not. In markets where such behavior is observed, it is possible to design a speculative trading strategy that captures the lost exercise proceeds. One such case is with an exchange-traded, American-style call option written on a stock that pays a dividend during its life.

The so-called *dividend capture* or *dividend spread* strategy involves identifying an in-the-money call option that should be exercised just prior to ex-dividend day. This is done by computing the call option value using the stock price net of the dividend amount (i.e., the ex-dividend stock price) and comparing it with the immediate exercise proceeds, $S_t - X$, where t represents the time just prior to ex-dividend. If the computed value is less than the call's immediate exercise proceeds, we sell the call just prior to the market close and simultaneously buy the underlying stock. The net cost of the position is the stock price less the call option price, that is, $S_t - C_t$.

Two things can occur at the open on the following morning. First, we may find that the call option holder has exercised his option, in which case we must deliver underlying stock. We receive the exercise price in cash, and deliver the stock. Our profit equals the exercise price less the net cost of the strategy on the day before the stock goes ex-dividend, that is, $X - (S_t - C_t)$. Since the call must have been trading at its floor value before the dividend was paid, that is, $C_t = S_t - X$, our profit equals zero. Second, we may find that the call option holder has forgotten to exercise his call or simply failed to recognize that it was optimal to do so. In this situation, we immediately buy back the call at its price after the dividend is paid, $C_{t+\varepsilon}$, and sell the stock at its ex-dividend price, $S_{t+\varepsilon} \equiv S_t - D$.[20] Since we were long the stock at the ex-dividend instant, we receive the dividend payment, D. Our profit, therefore, equals the dividend plus the proceeds from the liquida-

[20] At the ex-dividend instant, the stock price is assumed to fall by an amount exactly equal to the dividend payment.

tion of the position, $D + (S_{t+\varepsilon} - C_{t+\varepsilon})$, less the net cost at inception, $S_t - C_t$, or, equivalently, the drop in the call option value resulting from the dividend payment, that is, $\pi_t = D + (S_{t+\varepsilon} - C_{t+\varepsilon}) - (S_t - C_t) = C_t - C_{t+\varepsilon}$. Some refer to this strategy as a dividend capture strategy, although only part of the dividend is being captured. A more appropriate name is a dividend spread.

ILLUSTRATION 11.5 Identify and engage in dividend spread opportunity.

Consider a call option on a stock on the day prior to a stock going ex-dividend. The call has an exercise price of 25 and three months remaining to expiration. Its current price is 4. The stock price is 29, its volatility rate is 25% annually, and the amount of the cash dividend is 2. The risk-free rate of interest is 5%. Identify whether a dividend spread opportunity exists, and, if so, how to profit.

First compute the proceeds from exercising the option immediately. They are equal to the stock price less the exercise price, that is, 29 – 25 = 4. The fact that the call price is trading at or near its immediate exercise proceeds is the first indication that a dividend spread strategy may be profitable.

Next compute the value of the call immediately after the stock goes ex-dividend. Assuming no more dividends are paid during the call's life, the value of the call after the stock goes ex-dividend is

$$c = (29-2)N(d_1) - 25e^{-0.05(0.25)}N(d_2) = 2.76$$

where

$$d_1 = \frac{\ln(27e^{0.05(0.25)}/25) + 0.5(0.25^2)0.25}{0.25\sqrt{0.25}} = 0.7782$$

$$d_2 = 0.7782 - 0.25\sqrt{0.25} = 0.6532$$

$$N(0.7782) = 0.7818, \text{ and}$$

$$N(0.6532) = 0.7432$$

What this means is that it is optimal for the call option holder to exercise immediately, prior to the ex-dividend date. In doing so, he will receive exercise proceeds of 4. If he fails to do so, his option will decline in value to 2.76 after the dividend is paid. By choosing not to exercise, he implicitly loses 1.24.

Given that you know that early exercise is optimal and that not all call option holders exercise when they should, you can engage in a dividend spread by selling the call and buying the stock just prior to the dividend payment. This costs 25 (i.e., 29 – 4). If, on the following morning, you find that the call option holder has exercised, you deliver your stock against the call and receive 25 (i.e., the payment of the exercise price). Ignoring trading costs, you have neither made nor lost money. If, for some reason, the call option holder did not exercise, you should buy the call and sell the stock. The net proceeds are or 24.24. In addition, you receive the dividend from holding the stock, 2, bringing total proceeds to 26.24. Hence your profit is 1.24.

The profitability of engaging dividend spreads depends on the likelihood that the call option holder will exercise when he should. Naturally, trading costs should be factored into the decision about whether to engage in this type of speculative strategy.

Collar Agreements

Individuals such as chief executive officers of a firm often find themselves in a position in which a significant portion of their wealth is tied to the firm's share price. Such an undiversified (and, sometimes, illiquid) position is risky. One alternative is to sell the shares or, at least, a large portion of their shares. This strategy is usually not viable, however, because shareholders and analysts generally regard the liquidation of shares by corporate insiders as bad news about the prospects of the firm. Moreover, the gains from selling shares would be recognized immediately for tax purposes.[21]

To circumvent these problems, many CEOs use *stock price collars*. Specifically, they buy out-of-the-money puts, financing their purchase with the sale of out-of-the-money calls. The puts eliminate some of the downside price risk of the stock. At the same time, they continue to hold the stock, thereby participating in its upside, collecting its dividends, preserving its voting rights, and deferring taxes. The cost is, of course, that if the share price rises above the exercise price on the call, the shares may be called away. Alternatively, the executive can choose to cash settle the contract, in which case they continue to retain ownership of the stock and defer tax payment.

Collar agreements are generally consummated in the OTC market. The reason is that the put and call options tend to be long-term and deep out-of-the-money. Such options are thinly traded on exchanges, and, indeed, may not trade at all. In addition, OTC agreements allow the exercise prices to be adjusted so that the collar has no upfront cost.

ILLUSTRATION 11.6 Structure collar agreement.

Suppose the CEO of ABC Corporation has approached an OTC derivatives firm about structuring a collar on his shares. The CEO wants to be protected against the share price being below $36 per share in three years time. To pay for the insurance, he is willing to forfeit any share price gains beyond $X per share in three years. What is the maximum value of X that the OTC derivatives dealer will allow assuming the stock currently has a share price of $45 and a volatility rate of 35% annually, and pays no dividends? The risk-free rate of interest is 6%.

The CEO wants to be protected against "... the share price being below 36 in three years time ...", so we need to determine the fair value of a *European-style* put. Using the function, OV_OPTION_VALUE, from the OPTVAL Function Library, the value of the three-year European-style put is 3.294.

The next step is to find the exercise price of a three-year call option whose price is 3.294 so that the collar is costless. The exercise price must be solved for iteratively using a routine such as SOLVER in Excel. As this table shows, a call option with an exercise price of 95.187 has a value of 3.294:

[21] Prior to the Taxpayer Relief Act of 1997, individuals could borrow against a large stock position and defer taxes by "shorting-against-the-box." By short selling shares, the individual could lock in the price of the underlying stock and borrow up to 95% of the locked-in value for reinvestment. The Taxpayer Relief Act of 1997 targeted such trades and earmarked them as "constructive sales;" that is, transactions considered to be sales for tax purposes, even if no shares are exchanged.

Without Market Maker Fee	
Stock	
Price (S)	45.00
Volatility rate (s)	35.00%
Interest rate (r)	6.00%

Put Option		Call Option	
Exercise price (X)	36	Exercise price (X)	95.187
Years to expiration (T)	3	Years to expiration (T)	3
Value (P)	3.294	Value (C)	3.294
Difference in premiums	0.000		

In computing the maximum value of X, we assumed that the OTC firm charges nothing for its service. Instead, suppose that it embeds a one dollar per share fee to compensate for its costs of structuring and managing the risk of the assumed option position. What exercise price for the call will create a collar agreement with an upfront cost equal to zero?

The objective is now to find the exercise price of a three-year call option whose price is 4.294 (i.e. 3.294 goes to paying for the put; 1 towards the OTC firm's embedded fee). A call with an exercise price of 81.373 has a value of 4.294, as the following table shows.

With Market Maker Fee	
Stock	
Price (S)	45.00
Volatility rate (s)	35.00%
Interest rate (r)	6.00%

Put Option		Call Option	
Exercise price (X)	36	Exercise price (X)	85.551
Years to expiration (T)	3	Years to expiration (T)	3
Value (P)	3.294	Value (C)	4.294
Difference in premiums	1.000		

Variable Prepaid Forward Contracts

Variable prepaid forward (VPF) contracts are relatively new stock products. They arose from the fact that, while individuals can borrow against collared stock positions, banks will limit the amount that they can borrow to 50% of the market value of the stock if the individuals plan on investing in other equities.[22] VPFs circumvent this problem. A VPF is not regarded as a loan but rather as a

[22] For a lucid description of variable prepaid forwards, see "Having You Cake and Eating It, Too," *Bloomberg Wealth Manager,* April 2001, pp. 59–66.

sale of a contingent number of shares, which will be delivered at some future date, in exchange for a cash advance today. Since the number of shares, and thus their exact cash value, is not determined until maturity (based on the stock's price at the time), a VPF does not trip the constructive sale rule. It allows the individual to delay paying taxes while, at the same time, to hedge his stock price risk exposure and free up capital to invest in other securities.

The key elements of a VPF are as follows:

1. **Minimum share price.** The minimum share price is the least amount that the buyer of the VPF will receive for his shares to be delivered at time T. The minimum share price can be as much as 100% of the current price of the shares, but is often less.
2. **Cash advance.** At inception, the buyer of the VPF will receive a cash advance against the minimum share value, and the amount of the cash advance is the present value of the minimum share price. Thus the difference between the minimum share price and the cash advance is sometimes considered to be the implied financing cost of the trade.
3. **Maximum share price.** The maximum share price is the largest amount that the buyer will receive for his shares delivered at time T. The difference between the maximum and minimum shares prices will be at least 20 percentage points to avoid the constructive sale rule[23] and potential tax liability.
4. **Shares are pledged as collateral.** The shares are pledged as collateral with the seller of the contract.
5. **Optional sharing rule.** Some, but not all, VPFs have a sharing rule whereby the stock price appreciation above the maximum share price is shared by the buyer and seller of the contract (e.g., the buyer receives 10% while the seller receives 90%).
6. **Optional cash settlement.** The buyer, as his discretion can elect to settle the contract is cash rather than by delivery.

Perhaps the easiest way to understand the valuation of a variable prepaid forward is to examine its construction using the valuation-by-replication principle. Table 11.5 contains the four basic securities that comprise the VPF. First, the individual who buys the VPF is long stock, which he posts as collateral on the agreement. This trade is represented in the first row of the table. Ignoring dividends, the value of each share of stock at time T is $\tilde{S}_T$. The second row shows the cash advance. The VPF buyer is guaranteed a minimum share price of X_p at time T. The cash advance is received today and equals the present value of the minimum share price of the agreement, $X_p e^{-rT}$. By receiving the cash advance, the buyer has an implicit obligation to repay X_p at time T. To provide for this repayment, he buys a European-style put option with exercise price X_p. The cost of the put is $p(X_p)$ today. At time T, it pays $X_p - \tilde{S}_T$ if the put is in the money and 0 otherwise. Finally, to subsidize the cost of the put, the VPF buyer forfeits all share price gains above the maximum share price. Thus, he is also implicitly short a European-style call option whose exercise price equals the

[23] If the minimum and maximum share prices are equal, the VPF is tantamount to short selling the stock.

TABLE 11.5 Construction of variable prepaid forward transaction. Investor owns stock and posts it as collateral on risk-bond whose face value is X_p at time T. In addition, investor buys a collar with a downside protection price (i.e., a floor value) of X_p and a threshold appreciation price of X_c.

		Value on Day T		
Trades	**Initial Investment**	$S_T < X_p$	$X_p \leq S_T < X_c$	$S_T \geq X_c$
Long stock	$-S$	$\tilde{S}_T$	$\tilde{S}_T$	$\tilde{S}_T$
Cash advance (i.e., borrow present value of X_p)	$X_p e^{-rT}$	$-X_p$	$-X_p$	$-X_p$
Buy put with exercise price X_p	$-p(X_p)$	$X_p - \tilde{S}_T$	0	0
Sell call with exercise price X_c	$c(X_c)$	0	0	$-(\tilde{S}_T - X_c)$
Net portfolio value	$-S + X_p e^{-rT} - p(X_p) + c(X_c)$	0	$\tilde{S}_T - X_p$	$X_c - X_p$

maximum share price, denoted X_c. The value of the call today is $c(X_c)$. Its value at expiration is $-(\tilde{S}_T - X_c)$ if the call is in the money and is 0 otherwise. Thus, the value of a VPF may be written

$$VPF = -S + X_p e^{-rT} - p(X_p) + c(X_c) \tag{11.3}$$

Alternatively, the terminal values in Table 11.5 can be generated by buying a call with exercise price X_p and selling a call with exercise price X_c. Thus, in the absence costless arbitrage opportunities, it must also be the case that

$$VPF = -c(X_p) + c(X_c) \tag{11.4}$$

With the valuation tools in hand, let us examine the terms of a specific contract. On July 25, 2003, a living trust created by Mr. Roy E. Disney bought a VPF for 7,500,000 shares of Walt Disney common stock from Credit Suisse First Boston Capital LLC.[24] The settlement date of the contract was August 18, 2008 (or has a time to expiration of 5.0712 years). On that date, Mr. Disney, on behalf of the trust, nominally agreed to sell the 7.5 million shares of Disney for \$27.510 per share (i.e., 100% of the prevailing stock price at the time was entered).

At the time the VPF was entered, the trust received a cash advance of \$124,959.495 or \$16.66127 per share. At settlement, the trust is required to deliver a number of shares (or cash equivalent) as follows:

(a) all 7,500,000 shares if $S_T < 21.571$,

(b) $\left(\dfrac{21.571}{S_T}\right) \times 7{,}500{,}000$ shares if $21.571 \le S_T \le 32.6265$, and

(c) $\left(1 - \dfrac{10.8755}{S_T}\right) \times 7{,}500{,}000$ shares shares if $S_T > 32.6265$,

where S_T is the settlement price of the contract.[25] Note that the number of shares delivered depends on the stock price at time T, hence the use of the term "variable" in the security's name. Indeed, it is this feature that allows the contract buyer to avoid the constructive sale rule.

Now, consider the key elements of this VPF. The difference between the minimum share price 27.510 and the cash advance 16.66127 is usually labeled the

[24] The terms of this contract were drawn from the SEC Form 4, Statement of Changes in Beneficial Ownership filed by Mr. Roy E. Disney on August 20, 2003. Such documents are a matter of public record and can be obtained from the SEC's website, www.sec.gov, under Filings and Forms (EDGAR).

[25] For simplicity, you may want to consider the settlement price of the contract to be the closing price on the settlement date. For this particular contract, however, the settlement price is actually the volume-weighted average of the common stock for the 20 trading days preceding and including the settlement date.

implied financing cost.[26] The implied interest rate may be computed by solving $16.66127e^{r(5.0712)} = 21.571$ and is 5.0927%. Thus if the settlement price is below 21.571 at expiration, Mr. Disney can deliver the shares, in which case he has no further obligation. Alternatively, he can pay Credit Suisse the cash equivalent of the shares, S_T times 7.5 million.

The remaining contingencies are as follows. Under contingency (b), Mr. Disney receives all gains on the shares above 21.571 but below 32.6265. To provide Credit Suisse with its implicit loan repayment, Mr. Disney can deliver

$$\left(\frac{21.571}{S_T}\right)\times 7{,}500{,}000$$

shares of stock. Note that the number of shares is variable and depends on the share price. Recall that this is a requirement in order to avoid the constructive sale rule. Mr. Disney need not deliver the shares, however. Instead, he can pay the cash equivalent of the shares, that is,

$$S_T\times\left(\frac{21.571}{S_T}\right)\times 7{,}500{,}000$$

or $163,132,500. Under contingency (c), Mr. Disney must deliver

$$\left(1-\frac{10.8755}{S_T}\right)\times 7{,}500{,}000$$

shares of stock if the stock price exceeds 32.6265 at the contract's expiration. Again, note that the number of shares depends on the prevailing share. The cash equivalent in this range is

$$S_T\times\left(1-\frac{10.8755}{S_T}\right)\times 7{,}500{,}000$$

In summary, by entering a VPF contract rather than selling the shares of Disney outright, Mr. Disney generated more money up front than he would in after-tax proceeds of a sale, deferred the payment of the capital gains tax for at least the life of the contract, and did not lock himself into the sell decision, because at maturity he can make a cash settlement and keep his shares, or, alternatively, roll them into a new contract.

[26] Others refer to this discount as the *haircut* on the VPF.

Option Trading by Corporations

During the mid-1990s, a number of U.S. corporations, particularly high-tech firms, bought and sold options on their own stock. Typically, the trading involved either selling at-the-money puts in isolation or selling at-the-money puts and buying at-the-money calls (i.e., an option collar). The corporate option trading was usually linked to share-buyback programs, however, many firms were simply using options to profit from expected stock price increases.

Under the put writing strategy, the firm collects the put premium. In a rising market such as that experienced in the bull market of the mid-1990s, the strategy can be quite profitable since the puts expire out of the money and the firm gets to keep the cash. This cash can be used to buy back shares or held in reserve.[27] If the share price falls, however, the firm must buy back its shares at an above-market price. The bear market in the late 1990s proved disastrous, particularly for high tech stocks such as Microsoft and Dell.

For buyback programs, "cashless" collars can be more effective. A cashless collar involves buying a call of the firm's shares and selling a put in such a way that no money changes hands at inception. It differs from the put writing strategy in that the proceeds of the put are used to buy a call rather than generate a cash premium. Consequently, if the firm's share price rises, the firm has the opportunity to buy back its shares at a predetermined below-market price by exercising its call. Under the put strategy, the shares are bought back at the prevailing market price and are subsidized only by the cash premium collected at the outset. If the share price falls, however, the firm must buy back its shares at an above-market price, just as it did in the put writing-only strategy.

SUMMARY

This chapter focuses on derivative contracts written on common stocks. Although markets for both stock futures and stock options are active, stock option markets are the most active, with by far the largest amount of trading taking place in the United States. Cash dividends paid on the stock during the option's life may have an important impact on option value. The stock futures and option valuation results are summarized in Table 11.3.

Four stock option trading/risk management strategies are discussed. The first is a dividend spread and is speculative in nature. It is a trading strategy that is designed to profit from the fact that not all call option holders exercise when it is optimal to do so. The strategy involves selling an in-the-money call and buying the underlying stock just prior to the stock going ex-dividend. The second and third strategies are tailored to an individual with a large concentration in the shares of a single stock. A stock price collar, for example, is an OTC agreement that provides "costless" (or, perhaps more appropriately, "cashless") insurance against a stock price decline. The insurance is created by buying an out-of-the-money put and provides the individual with a guaranteed minimum price for the

[27] The cash is not taxable since a company does not recognize a gain or a loss when it deals in its own stock.

stock in the event of a price decline. Rather than paying for the put directly, however, the individual sells an out-of-the-money call. In the event of a large stock price increase, the individual forfeits gains above the call's exercise price. A variable prepaid forward strategy is similar to a stock option collar except that the hedger receives a cash advance in the amount of the present value of the put's exercise price upon entering the contract. The fourth and final strategy examines the practice of many firms to sell puts and/or buy calls on their own shares.

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APPENDIX 11A: EXACT VALUATION OF AMERICAN-STYLE CALL OPTION ON A DIVIDEND-PAYING STOCK

An American-style call option on a dividend-paying stock can be valued exactly. This is possible because there are only a finite number of rational exercise opportunities—one prior to each dividend payment and one at expiration. This appendix provides the valuation equation for an American-style call option whose underlying stock pays one dividend during the option's life. A compound option valuation approach is used.[28]

As discussed in earlier in this chapter, an American-style call option may be exercised just prior to when the stock goes ex-dividend because the stock price will fall by the amount of the dividend. Assuming that future stock price net of the present value of the promised dividend is log-normally distributed, the value of an American-style call option on a dividend-paying stock is

[28] Recall that European-style compound options were valued in Chapter 8.

$$C = S^x[N_1(b_1) + N_2(a_1, -b_1; -\sqrt{t/T})] \\ - Xe^{-rT}[N_1(b_2)e^{r(T-t)} + N_2(a_2, -b_2; -\sqrt{t/T})] + De^{-rt}N_1(b_2)$$

where

$$a_1 = \frac{\ln(S^x e^{rT}/X) + 0.5\sigma^2 T}{\sigma\sqrt{T}},\ a_2 = a_1 - \sigma\sqrt{T}$$

$$b_1 = \frac{\ln(S^x e^{rt}/S_t^*) + 0.5\sigma^2 t}{\sigma\sqrt{t}},\ b_2 = b_1 - \sigma\sqrt{t}$$

$N_1(b)$ is the cumulative univariate normal density function with upper integral limit b[29] and $N_2(a,b;\rho)$ is the cumulative bivariate normal density function with upper integral limits, a and b, and correlation coefficient, ρ.[30] As before, S is the current stock price, and σ is the stock's volatility rate. The stock is assumed to pay a dividend in the amount D at time t. The exercise price of the call is denoted X, and T is its time remaining to expiration. $S^x = S - De^{-rt}$ is the stock price net of the present value of the escrowed dividend. S_t^* is the ex-dividend stock price that satisfies

$$c(S_t^*, T-t; X) = S_t^* + D - X$$

The valuation equation shows that the American-style call option formula is the sum of the present values of two conditional expected values—the present value of the expected call value conditional on early exercise, $S^xN_1(b_1) - (X - D)e^{-rt}N_1(b_2)$, and the present value of the expected terminal call conditional on no early exercise,

$$S^x N_2(a_1, -b_1; -\sqrt{t/T}) - Xe^{-rT}N_2(a_2, -b_2; -\sqrt{t/T})$$

The term $N_1(b_2)$ is the risk-neutral probability that the call will be exercised early and the term $N_2(a_2, -b_2; -\sqrt{t/T})$ is the risk-neutral probability that the call will not be exercised early and will be in-the-money at expiration.

Note that as the amount of the dividend approaches the present value of the interest income that would be earned by deferring exercise until expiration, the value of the critical ex-dividend stock price, S_t^* approaches positive infinity, the values of $N_1(b_1)$ and $N_1(b_2)$ approach 0, the values of $N_2(a_1, -b_1; -\sqrt{t/T})$ and $N_2(a_2, -b_2; -\sqrt{t/T})$ approach $N_1(a_1)$ and $N_1(a_2)$, respectively, and the Ameri-

[29] We have added a subscript so as to distinguish the univariate normal from the bivariate normal.

[30] Details regarding the computation of the bivariate normal probability are contained in Appendix 8A of Chapter 8.

can call option formula becomes the dividend-adjusted BSM European-style call option formula shown in Table 11.5.

ILLUSTRATION 11A.1 Compute value of American-style call.

Compute the value of an American-style call option with an exercise price of 50 and a time to expiration of 90 days. Assume the stock is currently priced at $50 a share, has a volatility rate of 36%, and pays a $2 per share cash dividend in exactly 75 days.

First, check if the dividend is so small that early exercise will never be optimal. This is done using (3.16) from Chapter 3.

$$2 > 50[1 - e^{-0.05(90/365 - 75/365)}] = 0.103$$

Since early exercise is possible, you must now proceed with determining the critical ex-dividend stock price by solving

$$c(S_t^*, T - t; 50) = S_t^* + 2 - 50$$

The critical stock price is 49.060.

Next, compute the stock price net of the present value of the promised dividend.

$$S^x = 50 - 2e^{-0.05(75/365)} = 48.020$$

The value of the American call is now computed as

$$C = 48.020[N_1(b_1) + N_2(a_1, -b_1; -\sqrt{t/T})] - 50e^{-0.05(90/365)}[N_1(b_2) + N_2(a_2, -b_2; -\sqrt{t/T})] + 2e^{-rt}N_1(b_2)$$

where

$$t = 75/365, T = 90/365$$

$$\sqrt{t/T} = 0.9129$$

$$a_1 = \frac{\ln(48.020/50e^{0.05T}) + 0.5(0.36)^2 T}{0.36\sqrt{T}} = -0.0676$$

$$a_2 = -0.0676 - 0.36\sqrt{T} = -0.2464$$

$$b_1 = \frac{\ln(48.020e^{0.05t}/49.059) + 0.5(0.36)^2 t}{0.36\sqrt{t}} = 0.0134$$

$$b_2 = 0.0134 - 0.36\sqrt{t} = -0.1498$$

The bivariate normal probabilities are

$$N_2(a_1, -b_1; -\sqrt{t/T}) = 0.0520$$

and

$$N_2(a_2, -b_2; -\sqrt{t/T}) = 0.0484$$

and the univariate normal probabilities $N_1(b_1) = 0.5053$ and $N_1(b_2) = 0.4405$. The value of the American-style call is 3.445. The value of this call computed using the binomial method outlined in this chapter is 3.433. In other words, the binomial method has a 1.2 cent valuation error. The valuation computations for this illustration were performed using the OV_OPTION_VALUE_SO and OV_STOCK_OPTION_VALUE_BIN functions from the OPTVAL Function Library. A summary is shown here:

Stock Option Valuation Using Analytical Method

Stock		**Intermediate Computations**	
Price (S)	50	Years to expiration (T)	0.2466
Volatility rate (s)	36.00%	Time to ex-dividend in years (t)	0.2055
Dividend (D)	2.00	PVD	1.980
Time to ex-dividend in days	75	$S - PVD$	48.020
		$X[1 - e^{-r(T-t)}]$	0.103

Call Option		**Call Option Valuation (C)**	
Exercise price (X)	50	European	2.828
Days to expiration	90	American (analytical)	3.445
		American (binomial)	3.434
Market		No. of time steps 90	
Interest rate (r)	5.00%		